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COMPOSITE AERIAL VOLUME TABLES FOR CONIFER STANDS IN THE MOUNTAIN STATES[1]

Karl E. Moessner, Research Forester
Division of Forest Economics and Recreation Research

ABSTRACT

This note presents new composite aerial volume tables for conifer stands based on data from 460 Forest Survey field plots. The two tables list average board-foot and cubic-foot volumes per acre by total height and crown cover class, and are usable for stratification by photo volume class. Regression formulae and measures of accuracy for the tables are shown.

INTRODUCTION

The two composite tables published here were compiled for use in forest surveys performed by a combination of photo and ground sampling, as well as in volume estimates made from photo measurement alone. Aerial volume tables such as these are essential in making combined management-volume inventories where field sampling is based on stratification by photo volume class.[2]

WHY COMPOSITE TABLES?

Few interpreters in the Mountain States can identify species with assurance on the conventional 1:15,000 or 1:20,000 scale panchromatic aerial photos. At least ten commercially important species are found commonly within these Mountain States, and in the northern part of the area at least six species may occur on a single acre. Forest Survey now classifies mixed stands into timber types named for the species having a plurality of the number of dominant trees.[3] In many mixed stands the predominant species cannot be determined by photo interpretation. Some idea of the difficulty of this problem of interpretation may be gathered from the following tabulation of timber types on 460 Forest Survey field plots. Measurements from these plots provided the raw data for the two tables published here. For the tabulation below, plots having 80 percent or more of their volume in the key species were considered pure.

Key species	Percent of plots classified as pure	Key species	Percent of plots classified as pure	Key species	Percent of plots classified as pure
Douglas-fir	66	Whitebark and		Western hemlock	33
Ponderosa pine	88	limber pine	33	Western redcedar	45
Western white pine	14	Grand fir	12	Western larch	42
Lodgepole pine	67	Spruce--alpine fir	35	All plots	58

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[1] Including Montana, Idaho, eastern Oregon and Washington, South Dakota, Wyoming, Colorado, Utah, Nevada, Arizona, and New Mexico.

[2] Moessner, Karl E. A test of aerial photo classifications in forest management-volume inventories. U.S. Forest Serv. Intermountain Forest and Range Expt. Sta. Res. Paper INT-3, 16 pp. 1963.

[3] Until recently this was a plurality of merchantable volume.

COMPOSITE AERIAL VOLUME TABLE FOR CONIFER STANDS IN THE MOUNTAIN STATES

Gross cubic-volume[1] per acre by average stand height and crown cover

Stand height[2] (feet)	Crown cover[3] (percent)									
	5	15	25	35	45	55	65	75	85	95
	Ten cubic feet									
30	--	8	25	38	48	55	59	60	57	52
35	4	24	42	56	67	74	79	81	79	74
40	20	41	60	75	87	96	102	104	103	100
45	36	59	79	96	109	120	127	130	131	128
50	53	78	100	118	133	145	154	159	161	160
55	70	97	121	142	159	173	183	191	195	195
60	88	118	144	167	186	202	215	225	231	234
65	107	139	168	193	215	234	249	261	270	275
70	126	161	193	221	246	268	286	301	312	320
75	146	184	219	251	279	303	325	342	357	368
80	166	208	246	281	313	341	366	387	405	419
85	187	232	275	314	349	381	409	434	455	473
90	208	258	304	347	387	423	455	484	509	531
95	230	284	335	382	426	466	503	536	566	592
100	252	311	367	419	467	512	554	591	625	656
105	275	339	400	457	510	560	606	649	688	723
110	299	368	434	496	555	610	661	709	753	794
115	323	398	469	537	602	662	719	772	822	867
120	347	428	506	580	650	716	779	838	893	944
125	372	460	543	623	700	772	841	906	967	1024
130	398	492	582	669	751	830	905	976	1044	1108
135	424	525	622	715	805	890	972	1050	1124	1194
140	451	559	663	763	860	952	1041	1126	1207	1284
145	478	594	705	813	916	1016	1112	1205	1293	1377
150	506	629	748	864	975	1083	1186	1286	1382	1473
155	535	666	793	916	1035	1151	1262	1370	1473	1573
160	563	703	838	970	1097	1221	1341	1456	1568	1676
165	593	741	885	1025	1161	1293	1421	1545	1665	1781
170	623	780	933	1082	1227	1367	1504	1637	1766	1890

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[1] Gross volume, in all trees 5.0 inches d.b.h. and larger, from stump to 4.0-inch top. Volume from Forest Survey-total height-d.b.h. tables.

[2] Average height of dominant stand, photo measurement field checked.

[3] Crown cover of dominant stand, photo measurement.

Based on 460 1/5-acre plots taken in Montana, Idaho, South Dakota, Wyoming, Colorado, Arizona, and Utah.

Volume Equation

$V_C = 0.2444H + 0.0007969H^2 + 0.2329C - 0.001468C^2 - 0.001986HC + 0.00005933H^2C - 0.000003223HC^2 - 10.2863.$

Where V_C = Volume per acre in 10 cubic feet: H = stand height in feet; and C = crown closure in percent.

Multiple correlation coefficient (R) = 0.860. Aggregate deviation: Table 0.12 percent high.

Standard error of estimate = ±1370 cubic feet per acre, or 49.5 percent of the mean plot volume.

Forest Survey, Intermountain Forest and Range Experiment Station, Ogden, Utah, 1963.

COMPOSITE AERIAL VOLUME TABLE FOR CONIFER STANDS IN THE MOUNTAIN STATES

Gross sawtimber volume[1] by average stand height and crown cover

Stand height[2] (feet)	Crown cover[3] (percent)									
	5	15	25	35	45	55	65	75	85	95
					Hundred board feet					
40	5	8	9	10	11	11	10	8	6	3
45	13	17	20	22	23	23	22	20	17	12
50	22	28	32	35	37	37	36	33	30	24
55	31	38	44	49	52	53	52	49	45	39
60	40	50	58	64	68	70	70	68	63	57
65	49	62	72	81	86	89	90	88	84	78
70	59	75	88	98	105	110	112	111	107	101
75	70	88	104	117	126	133	136	136	133	127
80	80	102	121	137	149	157	162	164	162	156
85	91	117	139	158	172	183	190	193	193	188
90	102	133	158	180	198	211	220	225	226	223
95	114	149	178	204	224	241	252	259	262	260
100	126	165	199	228	253	272	286	296	301	301
105	139	183	221	254	282	305	323	335	342	344
110	152	200	244	281	313	340	361	376	386	390
115	165	219	267	310	346	376	401	419	432	439
120	179	238	292	339	380	415	443	465	481	490
125	193	258	317	370	415	455	487	513	532	545
130	207	279	344	401	452	496	533	563	586	602
135	222	300	371	434	491	540	581	616	643	662
140	237	322	399	469	531	585	632	670	702	725
145	252	344	428	504	572	632	684	728	763	791
150	268	367	458	540	615	680	738	787	828	860
155	284	391	489	578	659	731	794	849	894	931
160	300	415	521	617	705	783	852	912	964	1006
165	317	440	553	657	752	837	912	979	1035	1083
170	334	466	587	699	800	892	975	1047	1110	1163

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[1] Gross volume, International $\frac{1}{4}$-inch trees 11.0 inches and larger to a variable 5.5-inch minimum top diameter. Volume from Forest Survey-total height-d.b.h. tables.

[2] Average height of dominant stand, photo measurement field checked.

[3] Crown cover of dominant stand, photo measurement.

Based on 460 1/5-acre plots taken in Montana, Idaho, South Dakota, Wyoming, Colorado, Arizona, and Utah.

Volume Equation

$V_B = 1.0455H + 0.004599H^2 - 0.2100C + 0.01068C^2 - 0.008925HC + 0.0005473H^2C - 0.0003504HC^2 - 45.38.$

Where V_B = Volume in hundred board feet per acre: H = stand height in feet; and C = crown closure percent.

Multiple correlation coefficient (R) = 0.859. Aggregate deviation: Table 1.35 percent high.

Standard error of estimate = ±7747 board feet per acre, or 60.69 percent of the mean plot volume.

Forest Survey, Intermountain Forest and Range Experiment Station, Ogden, Utah, 1963.

Even if we could have located enough pure plots so that we could prepare an individual table for each species in this array, the mixture of species found on many sample locations would prevent effective application of the tables over much of the area.

The use of composite tables together with adjustment factors for differences in species and location has been well established in ground cruising. Composite aerial volume tables also have been published by several Forest Experiment Stations.[4] Adjustment factors computed from a subsample of the photo plots measured on the ground have been used to obtain a very satisfactory estimate of net scaled volume.[5] Such a procedure can also be used to calculate proration factors when volume is required by species or other breakdown.

CONSTRUCTION OF TABLES

The two composite aerial photo volume tables published here were prepared from data compiled from 460 Forest Survey field plots measured in Montana, Idaho, South Dakota, Wyoming, Colorado, Arizona, and Utah. The tables relate gross board-foot and cubic-foot volumes from field measurements on 1/5-acre plots to photo measurements of:

1. Average total height of the dominant stand. This measurement, though made on photos, was checked by comparing it with the average height obtained from ground measurement of dominant and codominant trees. Sample plots with height differences which exceeded the expected error and could not be reconciled were not used in the table.

2. Crown coverage of the dominant stand. This measurement was made on photos only since readings of comparable accuracy could not be obtained on the ground.

Average crown diameter of the dominant stand was also measured on photos and tested as a variable, but it was not included in the final tables.

Gross volumes,[6] computed from field data using Forest Survey total height d.b.h. tables, were:

1. Gross cubic-foot volume in all trees 5.0 inches d.b.h. and larger to a 4.0-inch top diameter.

2. Gross board-foot volume (International $\frac{1}{4}$-inch rule) in all trees 11.0 inches and larger to a variable top diameter not less than 5.5 inches.

The tables were constructed by machine compilation using a multiple regression analysis. The basic independent variables tested included three stand characteristics commonly measured on aerial photos: average total height (H), average crown diameter (D), and crown cover (C). Stepwise regression of some 45 possible combinations of these basic variables and their cross products indicated that each photo variable was significant, but crown diameter was of only minor importance. This analysis also indicated that each degree up to the fifth added to the efficiency of the equation. However, because of inadequate distribution of the basic data, the higher power equations appeared to produce unrealistic curves. For this reason the tables published here were prepared from equations that included only total height and crown cover and their squares and cross products.

The volume equation and the standard measures of accuracy accompany each table. The standard error of estimate shown for each table is based on data from the 1/5-acre plots used in preparing the tables. However, these tables present estimates of volume per acre; therefore, when field data are obtained by means of the Forest Survey 10-point location or any other method that provides a good estimate of the acre, these standard errors should be substantially reduced.

TESTS OF THE TABLES

These tables now are being tested empirically against others that were prepared from the same data but that include crown diameter as a variable. Comparisons also are being made between these tables and those prepared previously for individual species to determine whether species adjustment factors are required. These empirical tests should indicate whether a single composite aerial table can be used for all conifer species and locations in the Mountain States.

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[4] Including the Central States, Intermountain, Southern, Lake States, and Northeastern Stations.

[5] Moessner, Karl E. Estimating timber volume by direct photogrammetric methods. Soc. of American Foresters Proc., 1959. Pp. 148-151.

[6] These included both cull trees and cull portions of sound trees since neither can be recognized on photos.